Attachment 8: Quality Assurance

PROCEDURAL ASSURANCES

Procedural assurances while upgrading, calibrating, and applying the groundwater model will use the following techniques:

- **Using well documented groundwater model codes**. In order to utilize the software development currently taking place that will allow simulation of salt transport in streams and lakes, specialized versions of MODFLOW 2000 (MF2K-SSPA, Bedekar et al., 2011) and MT3DMS (MT3D-SSPA, Bedekar and Tonkin, 2011) will be used for the Zone 7 groundwater model. Although these codes are not official USGS or USACE versions of MODFLOW (Harbaugh et al., 2000) and MT3DMS (Zheng, 2010), they were developed in collaboration with the developers of the official codes. For example, two of the developers of official USGS code MODFLOW-NWT (Niswonger et al, 2011) are co-authors of the paper documenting MF2K-SSPA (Bedekar et al., 2011). As part of these collaborations, the newly developed code allowing simulation of salt and transport in streams and lakes and its documentation will be provided to the developers of official codes for possible future inclusion in the official codes. This will give the developers an opportunity to comment on the newly developed code prior to its use for this project.
- **Comparing groundwater flow model results to results using official model code.** Although the official codes are unable to simulate salt transport in streams and lakes as required for this project, the USGS code MODFLOW-NWT (Niswonger et al., 2011) will be used on equivalent flow model input to validate the specialized MF2K-SSPA code being used for the Zone 7 groundwater model.
- **Using a widely accepted graphical user interface (GUI) for error checking.** The model will be refined using the Groundwater Vistas GUI. This GUI is widely used throughout the world. It provides substantial error checking of model input files; reducing modeling errors by identifying potential mistakes before they are included in model simulations. Furthermore, GUIs provide quality checks by allowing visual review of model input and output. This visual review can identify both outliers in model inputs such as hydraulic conductivity, and unexpected model results such as unusual cones of depression. Specifically, maps of model input such as layer elevations and surface water configuration will be output from the GUI and compared to model-independent maps. Graphs will be created comparing simulated water and salt budgets to the input and salt water budgets.

- **Providing senior review of all techniques and results.** All techniques and results will be reviewed by senior hydrogeologists or engineers that are licensed in the State of California. The senior hydrogeologists or engineers will review all analysis techniques, assumptions, and results to make sure the groundwater model is defensible, accurate, and reasonable.

STANDARDIZED METHODOLOGIES

The modeling process will follow industry standard methods, practices, and procedures such as those discussed in Applied Groundwater Modeling (Anderson and Woessner, 1992), Groundwater Flow Modeling Guideline (Murray Darling Basin Commission, 2000), and Effective Groundwater Model Calibration (Hill and Tiedeman, 2007). These texts detail industry standard approaches for model development, model calibration, and model use.

MODEL CALIBRATION

The model will be calibrated to check model results against measured data. The model results will be compared to measured groundwater elevations, salt concentrations, drawdown and recovery during aquifer tests, streamflows, and lake levels. Comparisons will both be visual and statistical. Visual comparison will ensure that simulated trends in groundwater elevations match observed trends in groundwater elevations. Statistical analysis of results will compare simulated and observed groundwater elevations using mean errors, mean absolute errors, root mean squared errors, and root mean squared error divided by the range of observations. All of these statistical techniques are commonly used to quantify model accuracy, and are described in detail by Anderson and Woessner (1992).

PEER REVIEW

Zafer Demir, lead groundwater modeler at the Department of Energy's Lawrence Livermore Laboratory, will provide peer review of the Zone 7 model. He will review the calibrated model and assess whether the model is defensible, accurate, and reasonable based on model input included in the Vistas files and visual and statistical calibration results. He will also review the draft model report and provide comments for possible inclusion in the final report. Should Mr. Demir become unavailable to conduct the peer review, another groundwater modeling expert with equivalent qualifications will be selected to conduct the peer review.

PERSONNEL QUALIFICATIONS

The personnel for this project will consist of the following qualified Zone 7 staff, and its existing consultants.

ZONE 7 WATER AGENCY

The project will be managed by Tom Rooze, Associate Hydrogeologist and staff groundwater modeler at Zone 7. Previously, Mr. Rooze has overseen groundwater modeling efforts, specifically model updates and calibration implemented by HydroMetrics WRI. He also co-managed the previous work under the Local Groundwater Assistance grant. Technical assistance and internal peer review will be performed by Matt Katen.

TOM ROOZE

- California Professional Geologist # 6309
- California Certified Engineering Geologist # 1918
- BS, Earth, Atmospheric, and Planetary Sciences, MIT, 1985
- MS, Earth, Atmospheric, and Planetary Sciences, MIT, 1986
- 25 years geology and hydrogeology experience in California
- Project manager for Zone 7's Prop 84 (LGA) funded project administered by DWR for *Hydrostratigraphic Investigation of Aquifer Recharge Potential for Lakes C and D of the Chain of Lakes, Livermore, California*.

MATT KATEN

- California Professional Geologist # 5167
- California Certified Hydrogeologist # 336
- BS, Geology, Cal State University, Long Beach, 1978
- 32 years geology and hydrogeology experience in California
- Groundwater Section Manager, Zone 7 Water Agency
- Project Manager and Senior Hydrogeologist for Zone 7's *Well Master Plan, 2004*
- Senior Hydrogeologist for Zone 7's *Salt Management Plan, 2004*
- Principal Hydrogeologist for Zone7's *Groundwater Management Plan, 2005*

HYDROMETRICS WRI

Technical assistance will be provided by the following consulting personnel from HydroMetrics WRI:

CAMERON TANA

- California Professional Engineer # C 65822
- BS, Civil and Environmental Engineering, Stanford, 1998, with Distinction
- MS, Civil and Environmental Engineering, MIT, 1999
- 12 years professional environmental and groundwater consulting in California
- Vice-President of HydroMetrics WRI
- Lead groundwater modeler for most recent update and calibration of Zone 7 groundwater model.
- Presented calibration techniques for Zone 7 groundwater model at two national groundwater modeling conferences.
- Project manager for Central Water District's Prop 84 (IRWM) funded project administered by DWR that has a significant groundwater modeling component.

DERRIK WILLIAMS

- California Professional Geologist #6044
- California Certified Hydrogeologist #35
- BS Geology, UC Davis, 1982
- MS Hydrology, University of Arizona, 1987
- 25 years of professional groundwater consulting in California
- President of HydroMetrics WRI
- Lead modeler on numerous basin-wide groundwater models in California, most recently for the Seaside Basin.
- Has provided senior technical advice on Zone 7's groundwater model since 2005.

GEORGINA KING

- California Professional Geologist #8023
- California Certified Hydrogeologist #874
- BS, Engineering Geology, University of Natal, Durban, South Africa, 1992
- MS, Geohydrology, Rhodes University, South Africa, 1997
- 12 years of groundwater consulting experience in California.
- Has provided GIS expertise to numerous groundwater model projects in California, including for Central Water District's Prop 84 (IRWM) project administered by DWR.

LAWRENCE LIVERMORE NATIONAL LABORATORY

The peer review is planned to be conducted by Zafer Demir, Modeling Team Leader and hydrogeological engineer at the Department of Energy's Lawrence Livermore National Laboratory (LLNL):

ZAFER DEMIR – LAWRENCE LIVERMORE NATIONAL LABORATORY

- BS, Hydrogeological Engineering, Hacettepe University, Turkey, 1989
- MS, Mineral Engineering, UC Berkeley, 1992 (Fulbright Scholar)
- 20 years of experience in environmental hydrogeology
- As Modeling Team Leader of Environmental Restoration Department, coordinates all numerical modeling activities

If Mr. Demir should become unavailable to conduct the peer review, another groundwater modeling expert with equivalent qualifications will be selected to conduct the peer review.

REFERENCES

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Harbaugh, A.W., E.R. Banta, M.C. Hill, and M.G. McDonald. 2000. MODFLOW-2000, the U.S. Geological Survey modular ground-water model -- the Ground-Water Flow Process: U.S. Geological Survey, Reston, VA, variously p.

Hill, M.C. and C.R. Tiedeman. 2007. Effective groundwater model calibration; with analysis of data, sensitivities, predictions and uncertainty. John Wiley & Sons, Inc., Hoboken, NJ, 455 p.

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Zheng, C. 2010. MT3DMS v5.3 Supplemental User's Guide, Technical Report to the U.S. Army Engineer Research and Development Center, Department of Geological Sciences, University of Alabama, 51 p.

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